A leading and down-to-earth instrument manufacturer

POWEREACH®

A high-tech company

ISO9001:2000

JK99C Automatic Tension Meter

Operation Manual

POWEREACH®

1. The design, specification, relevant software and operational manual of this instrument are subject to continuous update. Updates will be made without further notice to customers, but will be announced in the website of POWEREACH®.
2. POWEREACH® will be grateful for your kind advice in regard to anything needing improvement in this instrument or relevant software, or the operation manual.
3. Please carefully read and fully understand the operation manual for relevant software and hardware of this instrument before use. POWEREACH® shall not be held liable for any consequence as a result of improper use of the instrument.
4. This operation manual or any part thereof shall not be referenced for any other purpose without prior authorization from POWEREACH®.
5. POWEREACH® disclaims any responsibility for the profit or loss from commercial use of this instrument.

Safety Signs

The following marks and symbols contained herein are intended to help you correctly and safely use this instrument and avoid personal injury and property loss. Please understand the meanings of these marks and symbols before reading this operation manual.

Mark

	Any operation performed in violation of this mark may cause personal injury or property loss.

Signs

The following signs identify dangers that may cause personal injury or property loss in different degrees.	
	The most severe personal injury or property loss is probably caused.
	Severe personal injury or property loss is possibly caused.
	Middle level personal injury or property loss is possibly caused.

Symbols

The following symbols provide certain safety warnings that help prevent personal injury or property loss.	
	Personal injury may be caused.
	Smoke or fire may be caused.
	An electric shock may be caused.
	An explosion may be caused.
	Power supply should be disconnected for safety.
	Information on correct operation

Foreword

What you have chosen is the JK99 series automatic tension meter produced by Shanghai POWEREACH® Digital Technology Equipment Co., Ltd. Being compatible with platinum plate method and platinum ring method, this is the most commonly used instrument for precise measurement of middle-range surface tensions (please select the JJ2000 spinning drop surface tension meter if you need to measure ultra-flow surface tension).

Surface tension is one of fundamental properties of liquids, in particular, of surfactant aqueous solution. By replacing chemical methods with physical methods, automatic tension meters can rapidly measure the surface tension values of liquids of various kinds. This instrument is widely used in myriad sectors. For example, it helps people in water and electricity sectors better monitor the quality of insulation oil; assist researchers in petroleum and chemistry sectors in liquid analysis, and plays a role in teaching field. Also, this instrument can measure the liquid-liquid interfacial tension.

You are required to carefully read this operation manual, which is believed to greatly help you with research and quality control, to correctly use this instrument.

Main Functions and Features

- Supporting platinum plate method and platinum ring method (accessories and software for both methods are supplied with the instrument), this instrument sees broad applications and helps users align themselves with upstream and downstream businesses and test entities in respect of technical data;
- The entire operation process together with data collection is automated. Intelligence minimizes the possibility of human errors;
- Key parts (including sensors) are imported, producing high precision and good repeatability;
- Window-based software with Chinese display and friendly user interface supports long-term recording of measurement curves, automatic data generation, and saving and printing of data.
- Optional accessories like a constant temperature platform and an LCD are available to meet diverse needs of users.

- Considerate design ensures the instrument's adaptability to common test environment in collaboration with ordinary personal computers and its stable operation and low noise.
- The product is independently developed by POWEREACH®, which owns the title to all intellectual property rights to the product and therefore is able to guarantee the entitlement of users to maintenance, upgrading and service. Delivery, installation, commissioning and personal training are also provided.

Foreword

Main technical parameters

1. Test method: Hanging plate method/hanging ring method
2. Measuring range of the surface tension: 0 mN/m~1000 mN/m
3. Definition: <0.05 mN/m
4. Sampling cycle: 10 seconds to 200 seconds
5. Voltage of power supply: AC220V
6. Frequency of power supply: 50 Hz
7. Maximum power: <150W
8. Working temperature: room temperature
9. Working humidity: 30％～85％ RF

Instrument Introduction

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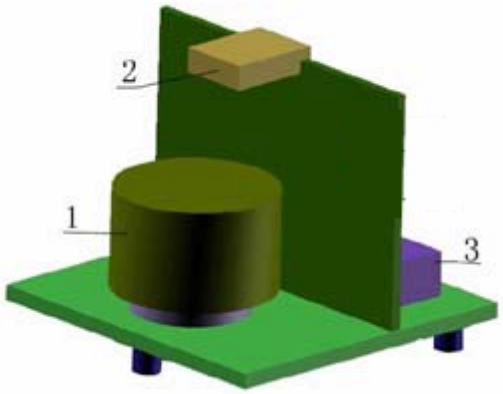
Instrument Introduction

➢ Instrument structure

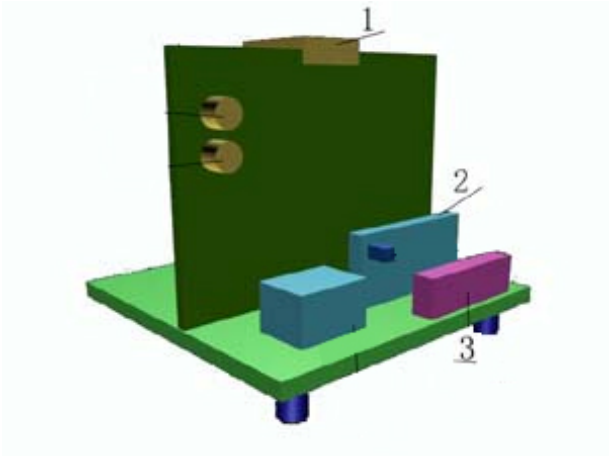
The front view of the tension meter is shown in Figure 1.



（1）platform (2) sensor (3) power supply

Figure 1 Front view of the tension meter

The back view of the tension meter is shown in Figure 2.



(2) sensor (2) control panel (3) interface panel

Figure 2 Back view of the tension meter

Instrument Introduction

➢ Output terminal

- This instrument can operate alone.
- If computer connection is required, the recommended minimum computer configuration is as below:

  2G memory; 500M hard drive space; one normal COM1 or USB port.

➢ List of components

- an automatic tension meter, consisting of: a motor system, a circulation thermal insulation platform capable of connecting to thermostatic bath, a micro force sensor
- accessories of automatic tension meter, including:

serial port extension line	1
crystallizing dish	2
platinum plate and platinum ring	1 for each
tweezers	1 pair
alcohol burner	1
hard drive CD	1
instructional manual	1

Working Principles

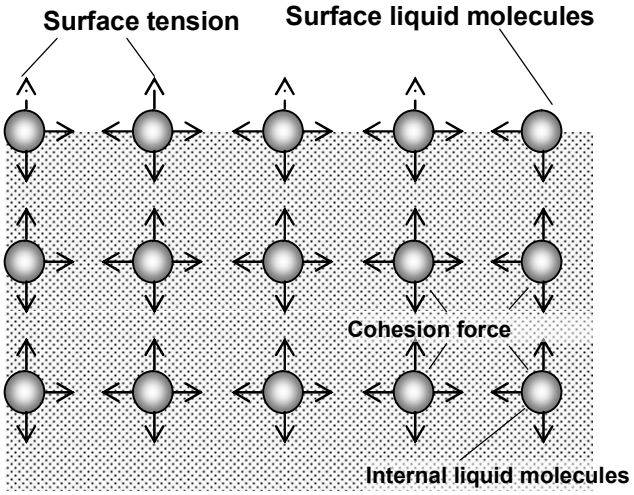
➢ What is surface tension?

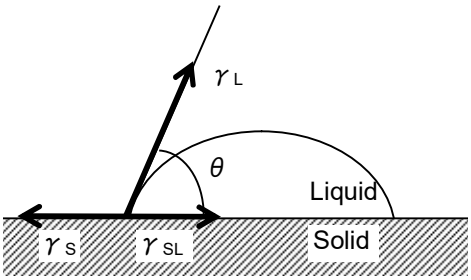
As is known to all, we can explain properties of a liquid through the attraction between two molecules. This inter-molecular attraction is called molecular cohesion or van der Waals force. Surface tension, interfacial tension and other similar phenomena are basic physical phenomena that can explain this force.

Specifically, the force imposed upon molecules within a liquid is different from that on the liquid. Internal molecules receive symmetric and balanced forces while surface ones are only attracted by internal molecules, but the force that can counterbalance this attraction is not available. That is to say, surface molecules are pulled toward the liquid. In other words, this force tends to minimize the surface area such that this state can approach an equilibrium. This is explained in thermodynamics in the following way: This force, "surface tension", intends to minimize the surface energy of the liquid system; namely, the force is the free energy per unit area (J/m^2) and also the minimum energy required to create or create a unit area of the surface. The value of free energy per unit area is the same as the value of the surface tension (N/m). Out of habit, surface tension is usually used to describe surface free energy, which plays a vital role in physical and chemical properties of liquid surface. The dew drops on lotus leaves in the morning and arch water surface in cups are the result of surface tension.

Please refer to the following illustration.

Working Principles





$\gamma_S = \gamma_L \cdot \cos\theta + \gamma_{SL}$ Young equation

γ_S : solid surface tension
γ_{SL} : solid/liquid surface tension
γ_L : liquid surface tension
θ : Contact angle

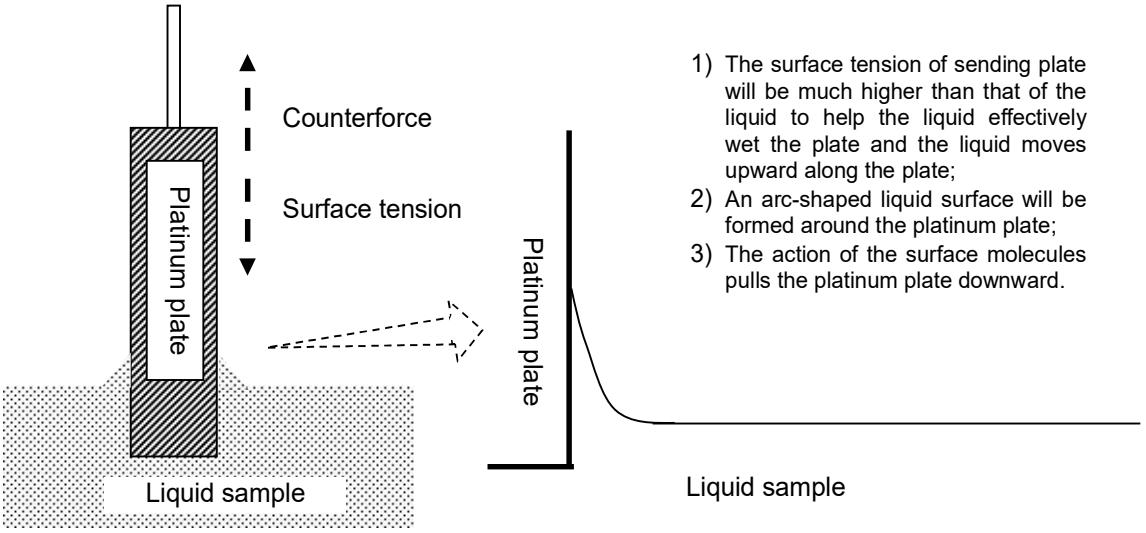
➢ Platinum plate method

Once the platinum plate is immersed into the liquid to be measured, the plate is pulled down due to the surface tension of the liquid. The immersion will stop when the surface tension and another force reach equilibrium. At this moment, the equilibrium sensor supplied with the instrument will measure the immersion depth and then calculate the surface tension of the liquid.

The specific test procedures are: (1) place the platinum plate into the liquid; (2) the sensor measures the equilibrium value when the platinum plate is stably immersed into the liquid; (3) the surface tension is converted from the sensed equilibrium value and displayed on the instrument.

Please refer to the following illustration.

Working Principles



1) The surface tension of sending plate will be much higher than that of the liquid to help the liquid effectively wet the plate and the liquid moves upward along the plate;
2) An arc-shaped liquid surface will be formed around the platinum plate;
3) The action of the surface molecules pulls the platinum plate downward.

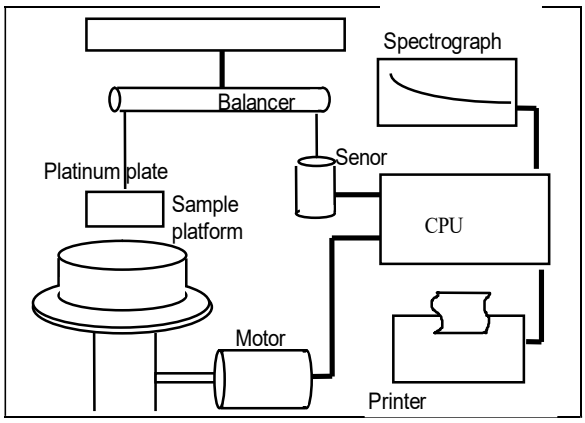
$$P = mg + L\gamma \cdot \cos\theta - sh\rho g$$

Counterforce =plate weight+ total surface tension –buoyance applied to the plate
(upward) (downward) (upward)

m : platinum plate weight
g : gravity (9.8N/ Kg)
L : platinum plate perimeter
γ : liquid surface tension
θ : contact angle between liquid and the platinum plate
s : cross section area of the platinum plate
h : immersion depth of the platinum plate
ρ : liquid density

●Hardware:

Once contacting the liquid sample, the platinum plate will be pulled down by the surface tension of the liquid sample. The sensor measures this equilibrium force through the balancer and sends the force to CPU.



●Software:

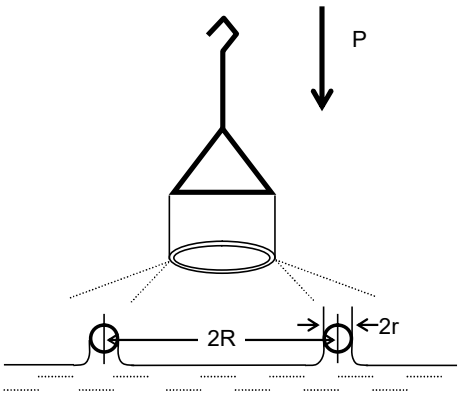
After receiving the force sent from the senor, CPU performs calculations and converts this force to the surface tension value.

●Display and output devices:

The surface tension value is outputted on the computer monitor. It can be saved and stored in the hard disk or printed immediately if the computer is connected to a printer.

Working Principles

➢ Platinum ring method



Where

P: the downward force applied to the ring
2r : plate (metal wire) diameter
2R: inner diameter of the ring (distance between centers of the two metal wires)

Surface tension $\gamma = \frac{P}{4\pi R} F$

Due to its wide application to du Nou surface tension meter, this method is also called *du Nouy* method. It is popular in various applications thanks to its ease for operation. Since a liquid ring will force between the liquid sample and the platinum ring, this method is named platinum ring method.

The specific procedures of platinum ring method: (1) slowly immerse the platinum ring into the liquid; (2) slowly raise the platinum ring, namely, the liquid surface drops down in relative to the platinum ring, such that a liquid column is formed under the platinum ring and finally becomes separate from the platinum ring.

This method is intended to measure the maximum value, which occurs when the platinum ring is about to separate from the liquid sample. The accuracy of the surface tension converted from this maximum value is up to the viscosity of the liquid.

F in the above equation is a correction coefficient, the value of which is dependent on diameter of the ring and properties of the liquid. This correction coefficient is of great importance since the pulling down force is not necessarily vertical and the liquid pulled up by the platinum ring is complicated.

Generally, F is calculated through *Zuidema & Waters* equation:

$$(F - a)^2 = \frac{4b}{\pi^2} \bullet \frac{1}{R^2} \bullet \frac{P}{4\pi R\rho} + C$$

a : 0.7250

b : 0.09075 $m^{-1}s^2$

c : 0.04534 – 1.679 r / R

r : Radium of the platinum wire

2R : Inner diameter of the platinum ring (the distance between centers of the two wires)

ρ : Difference of densities between upper layer and lower layer of the liquid

➢ Comparison of platinum plate method and platinum ring method

Du Nouy ring method had been used in measurement of surface tension for about 40 years before other measurement devices were studied and produced. Wilhelmy platinum plate method was born in 20 years ago. But, more and more people are using platinum plate method to measure surface tension, mainly attributed to the following weakness of the du Nouy ring method:

- **Difficulty in measuring the surface tension of highly viscous liquid;**

  This is because the upper layer of inner side of the platinum ring is more pulled down by the liquid sample.

- **Difficulty in measuring the time-varying surface tension;**

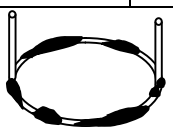
  This is because the platinum ring can only measure the surface tension at the moment when the ring leaves the liquid.

- **Difficulty in maintaining the instrument preciseness;**

  The platinum ring is easily deformed and its size affects the measurement of surface tension.

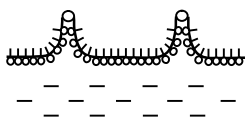
■Reference data: (mN/m)

	Paints	Solutions containing surfactants
Platinum ring method	35.4	32.1
Platinum plate method	31.3	28.8



◆ **Paints**

Place the viscous material above the platinum ring, and then start the measurement process.



◆ **Solutions with surfactants**

Surfactants are low in concentration and disperse incessantly.

Preparation

➢ Unpacking

1. Inside the carton are standard components, the tension meter and other accessories
2. Inspect whether the standard components and accessories match what are included in the packing list

CAUTION

- Handle carefully during the unpacking process.
- Take out of the tension meter with two hands.
- Do not apply a force to either the sample platform or the sensor since such force may cause product damage.
- Please contact with POWEREACH® or your dealer or distributor if any transport damage is found and do not dismantle the instrument on your own.

➢ Installation

- Connect the nine-pin cable to the instrument and the COM1 port of the computer. If no COM1 port is available, please use the USB port instead. The power supply cable is connected to both the instrument and its socket. Please refer to Figure 3.

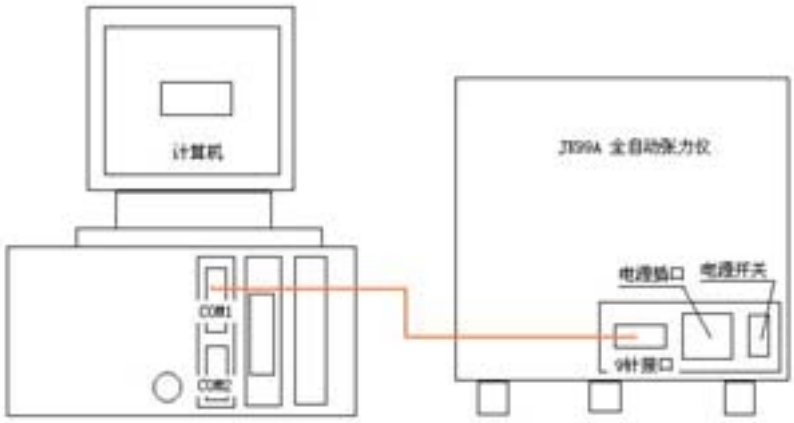


Figure 3 Connection diagram of the instrument

- Adjust the instrument until it is level. Place the spirit level on the center of the hoist platform by adjusting the three feet of the instrument so that the spirit level moves to the center.
- After the instrument and computer are connected, set the monitor by

selecting 64K colors and 800*600 pixels for the screen, as shown in Figure 4.

Figure 4 Monitor setting

CAUTION

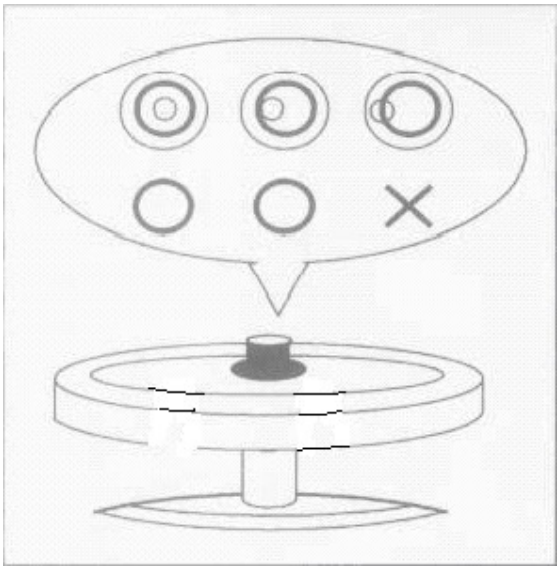
- In order to prevent instrument failure and damage, you should avoid the following conditions in the installation process:
  —incline —a lot of dust —vibrant shaking and instability —excessive humidity
  —extreme high or low temperature or dramatic temperature change
  —any place where corrosive gas is stored or where operations are not easily performed
- Since an alcohol burner used for cleaning the platinum plate and platinum ring is included in the instrument, do not use any flammable substance in installation process.
- Install the automatic tension meter on a vibration-less platform, a vibration-proof platform is recommended.
- Adjust the automatic tension meter to level with a level ruler.
- Pay attention to interference of high voltage to the power supply of the automatic tension meter and have the instrument properly grounded.
- Neither wireless communication device nor any interference source with a certain power may be used in the room where the automatic tension meter is operating.

Preparation

CAUTION

- Cut off all power supplies of the instrument before cable connection. The power supply cable must be the last one to connect. Connection of a power supply cable that is live may cause an electric shock.
- Do not plug power supply cable or touch the live instrument with a wet hand, which may cause an electric shock.
- Please use the required AC voltage because wrong voltage may damage cables, cause an electric shock, fire or burn.
- One socket is connected to only one electric appliance. Since socket may easily cause overloading, a cause of fire.

➢ Leveling



Place the spirit level on the sample platform and level the platform by adjusting the three feet under the tension meter. Observe the spirit level from a bird's view during the leveling process to control the spirit level within the ring.

CAUTION

- After levelling, inspect if the automatic tension meter is secured without shaking.

Basic Operations

The following precautions must be remembered before the formal measurement:

First, about the instrument:

1. The tension meter must have been warmed-up for 10 minutes, i.e., the meter cannot be used before it is turned on and becomes stable (which takes about 10 minutes). This procedure is to warm-up the senor.
2. Before the use of the instrument, hang the platinum plate to the hook for resetting, which is performed in the following two procedures: (1) reset with the software when there is a huge difference between the displayed value and zero. (2) after resetting with the software, perform a coarse tune (when displayed value is larger or lower than zero by 1mN/m) and a fine tune (when displayed value is within 1mN/m) to reset. The displayed value must be as close to zero as possible.
3. Before each measurement, the platinum plate and glass vessel must be cleaned. The cleaning methods are described as below:
   (1) For platinum plate: Generally, rinse the plate with running water (distilled water is the best), dry the plate with an alcohol burner until the entire plate turns slightly red (about 20-30 seconds) and hang the plate for use.
   (2) For glass vessel: Clean and dry the glass vessel before the test; during the measurement, wet the vessel by the sample to keep the effectiveness of the measured data.
   (3) Never have the platinum plate contact any liquid before it is cooled down because contact may cause it to be deformed, which affects the accuracy of the measurement.
4. If the temperature control is required, please purchase an additional temperature control device.

Second, about measuring process:

1. Dirty platinum plate or glass vessel may cause measurement errors and low repeatability. For example, if you slightly touch the water during the measuring process, this instrument will immediately display a new value, because the oil on the operator's finger has changed the surface property of the water.

2. Liquid densities have been corrected for this instrument. Refer to the list of corrections attached hereto for higher precision measurements.
3. To provide precise measurements, the platinum plates provided by POWEREACH® are specially customized and have received special treatments suitable to different samples. POWEREACH® shall be held no liable for any inaccuracy caused by your change of the platinum without prior consent of POWEREACH®.
4. The natural conditions that affect the measured value from chemical and physical principles are (1) temperature and (2) air pressure. Generally, the surface tension of a liquid decreases as the temperature increases. So, it is advisable to purchase a temperature control device if the varying change is not acceptable to you.
5. The measurement process should be accelerated for highly volatile liquids; in this case, the "high speed" button should be selected. A highly volatile liquid easily sticks to the platinum plate, so clean the platinum plate before a repeated test.
6. Evaporation that occurs during the test will cause the surface tension to decrease.
7. Although the quantity of liquid to be measured in the glass vessel does not affect the measurement accuracy, please ensure the liquid is 5 mm in depth for about 15 ml.
8. When you want to observe changes of surface tension by adding any surfactant to the liquid, please ensure that the surfactant does not touch the platinum plate.
9. Up or down movement of the sample platform during the measurement process will affect surface tension in this way: upward movement reduces the surface tension and downward movement increases. Both are the causes of errors.

✧ Troubleshooting

First, the measured value is lower than the actual value：

1. The platinum is not clean (the most likely cause);

2. Resetting is not completed;
3. The glass vessel is not rinsed completely such that any residue from the last test remains;
4. Your hand touches the sample;
5. The sample to be measured is a surfactant or a mixture, whose property is time-varying. All samples must be stirred evenly and prepared in the same ratio; and had better receive the test after being kept static for the same period;
6. Wettability of the liquid is not high enough or the liquid is viscous and volatile.

Second, the measured value is higher than the actual value:

1. The resetting is not performed accurately;
2. The sample to be measured is a surfactant or a mixture, whose property is time-varying. All samples must be stirred evenly and prepared in the same ratio; and had better receive the test after being kept static for the same period;
3. The sample is viscous.

Third, poor repeatability:

1. The platinum plate is not clean enough;
2. Properties of the sample to be measured vary as time changes;

Fourth, abnormal data display:

1. Internal data cables are not properly connected;
2. The instrument fails and needs to be repaired.

Fifth, automatic testing cannot be performed:

1. The liquid is highly viscous; in this case, perform the operation procedures tailored to high viscous liquids;
2. Surface tension value of the sample is low; in this case, correct the part of the value in respect of which the testing process is stopped automatically;
3. The displayed value after the platinum plate is pre-wetted is greater than 6 mN/m.

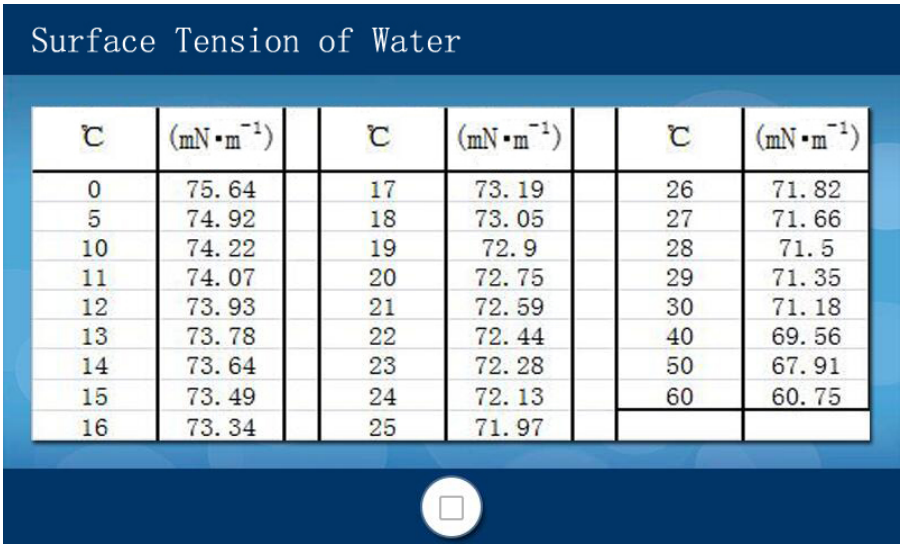
✧ Test methods:

Standard test method (the most common)

First, let us get to know the information about online and offline modes.

There are 6 buttons on the main screen. Once licked, each of them will direct to a corresponding operation screen. The six operation screens are for platinum plate testing, platinum ring testing, instrument calibration, surface tension of water, surface tension of alcohol and contact us information and will be detailed in the following sections.

Click "surface tension of water" button to enter the following screen.

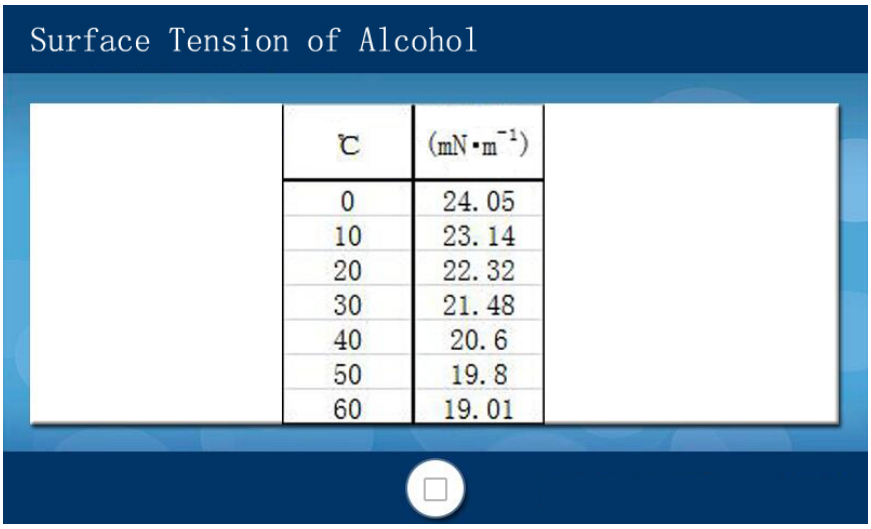


℃	(mN·m^{-1})	℃	(mN·m^{-1})	℃	(mN·m^{-1})
0	75.64	17	73.19	26	71.82
5	74.92	18	73.05	27	71.66
10	74.22	19	72.9	28	71.5
11	74.07	20	72.75	29	71.35
12	73.93	21	72.59	30	71.18
13	73.78	22	72.44	40	69.56
14	73.64	23	72.28	50	67.91
15	73.49	24	72.13	60	60.75
16	73.34	25	71.97		

The measured values of standard redistilled water are provided on the screen. Users can find and compare the standard values with their own.

Basic Operations

Click "surface tension of alcohol" button to enter the following screen.



The measured values of standard alcohol are provided on the screen. Users can find and compare the standard values with their own.

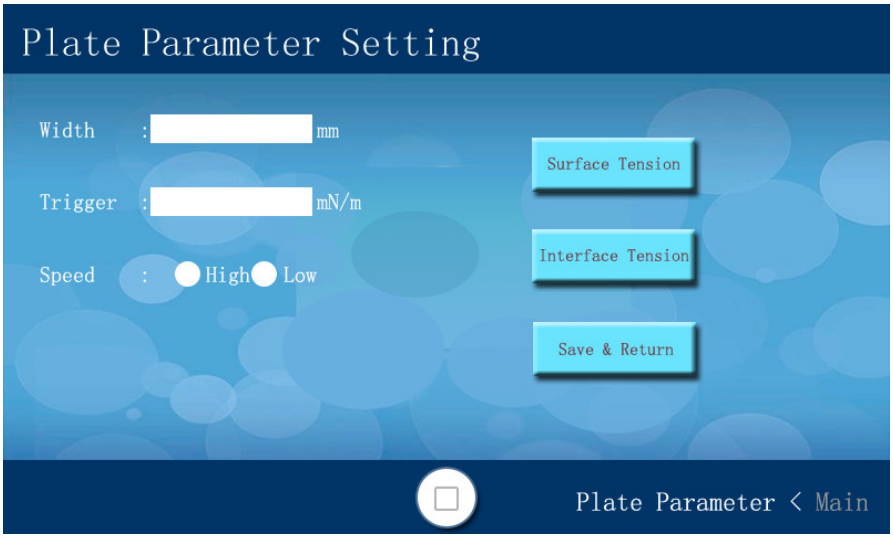
Click "weight correction" button to enter the following screen.

If surface tension of the liquid to be measured is higher than 500mN/m, select a larger range within the measurement range. The default mode is general mode. NMB sensors do not support larger range option.

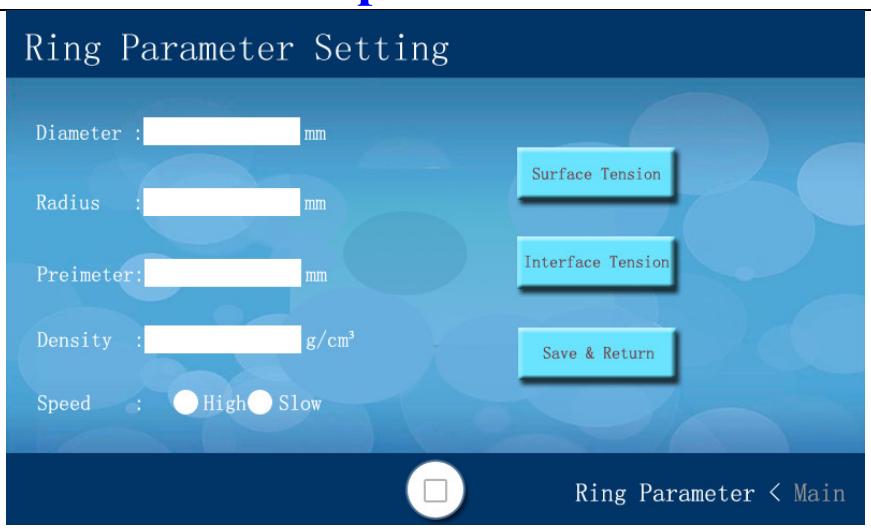
Click "contact us" button to enter the following screen.

You can get in touch with POWEREACH® by the means provided on the screen once encountering any problem in the use of the instrument.

The following are the two respective screens under two modes. Please pay attention to the items on the left bottom part of the screen. The items are respective parameters for platinum pate method and platinum ring methods in two modes.



Parameter setting for platinum plate method



Parameter setting for platinum ring method

Platinum plate measuring screen

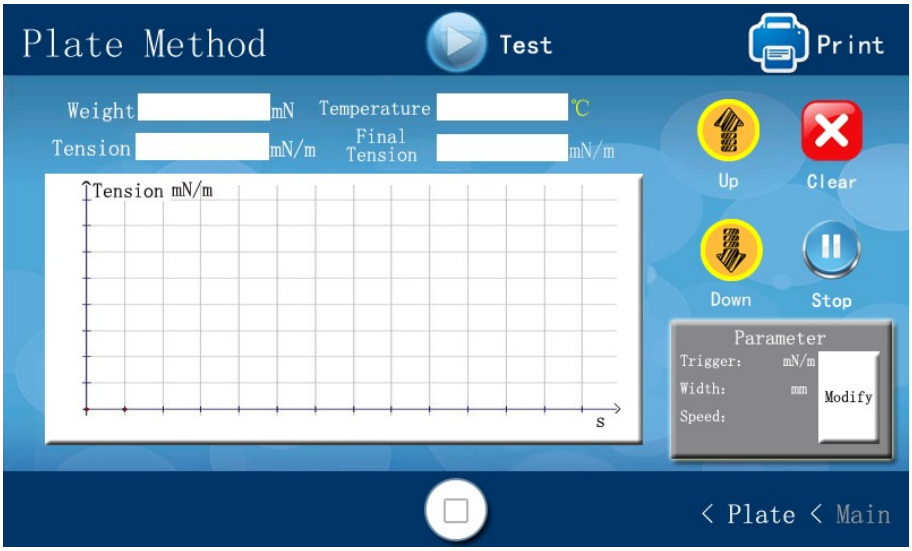


Figure 1 Surface tension measuring screen

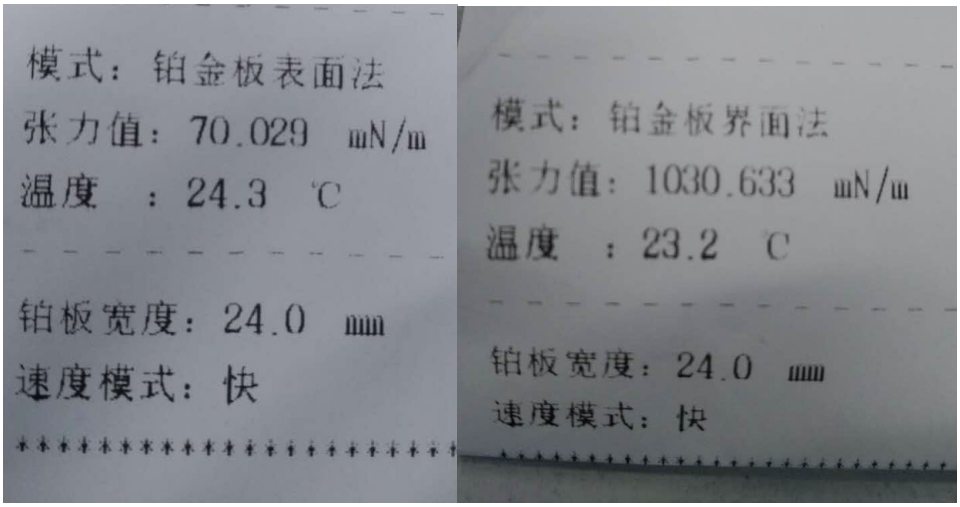
Figure 1 and Figure 2 are screens in the case of platinum plate method. Click the "platinum plate method" on the main screen to enter this screen.

If it is first time to operate this instrument or any parameter needs to be corrected, click the "modify" button to enter the screen shown in Figure 1 for correcting the parameters. Fill in the plate width and the surface tension triggering value. Select the speed. Also, you can select the measuring mode of the plate method, i.e., surface tension or interfacial tension.

Click "save & return" to get back to the measuring screen Figure 2. The parameters will be displayed in the parameter panel on the right bottom part of the screen.

Basic Operations

On the plate method measuring screen, click "clear" button before the measurement (or clear the data from the last measurement), click "test" to start the surface tension test process and the measured data, such as real time weight, temperature, surface tension and final surface tension, will be displayed in the text box on the screen. Click "print" to print the result of the last operation.



The left picture shows the general range mode and the right the large range mode.

Other buttons, such as up, down and stop, can independently move the platform to help with the measurement process.

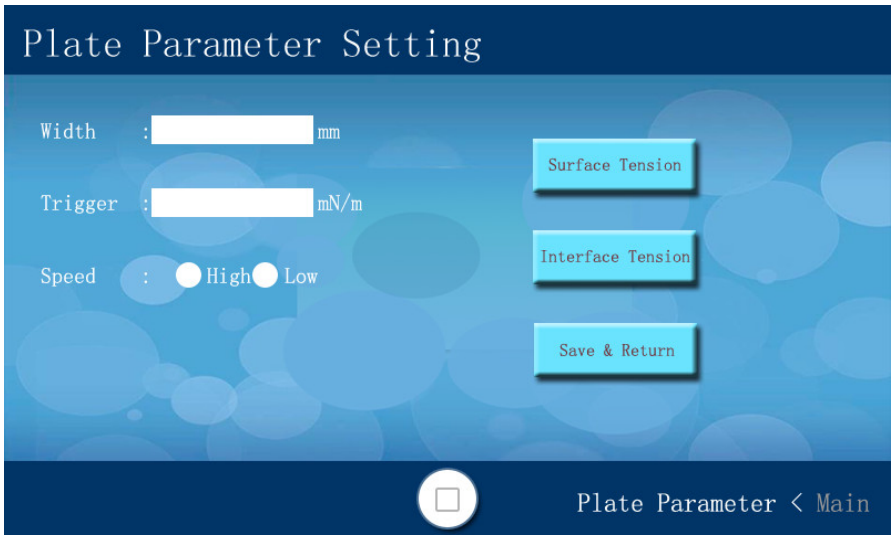


Figure 2 Parameter setting for platinum ring method

Platinum ring measuring screen

Figure 3 and Figure 4 are screens in the case of platinum ring. Click the "platinum ring method" on the main screen to enter this screen.

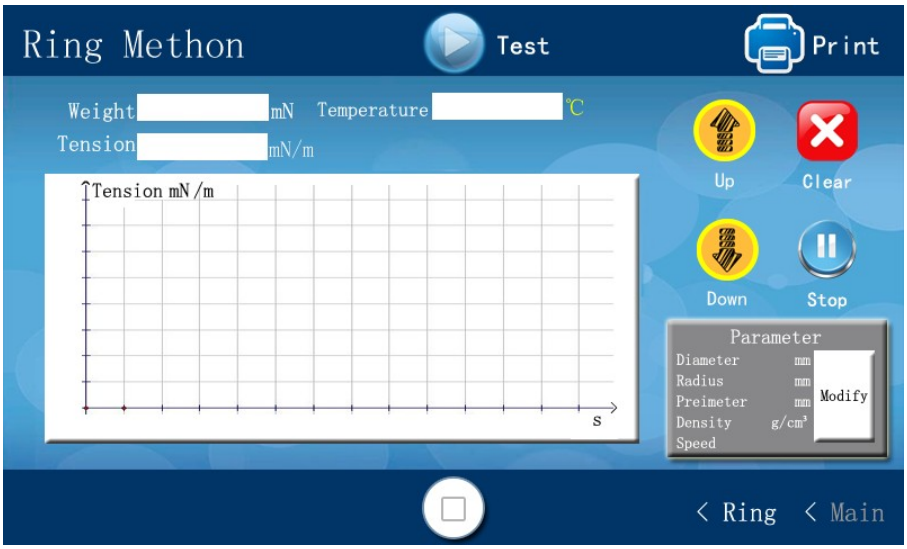


Figure 3 Platinum ring measuring screen

If it is the first time to operate the instrument or any parameter needs to be corrected, click the "modify" button to enter the screen shown in figure 3 for correcting the parameters. Fill in the outer diameter in the "diameter" box and density difference in the "density" box. Select the speed. Also, you can select the measuring mode of the ring method, i.e., surface tension or interfacial tension.

Click "save & return" to get back to the ring method measuring screen. The parameters will be displayed in the parameter panel on the right bottom part of the screen.

On the ring method measuring screen, click "clear" button before the measurement (or clear the data from the last measurement), click "test" to start the surface tension test process and the measured data, such as real time weight, temperature, surface tension and final surface tension, will be displayed in the text box on the screen. Click "print" to print the result of the last operation.

Other buttons, such as up, down and stop, can independently move the platform to help with the measurement process.

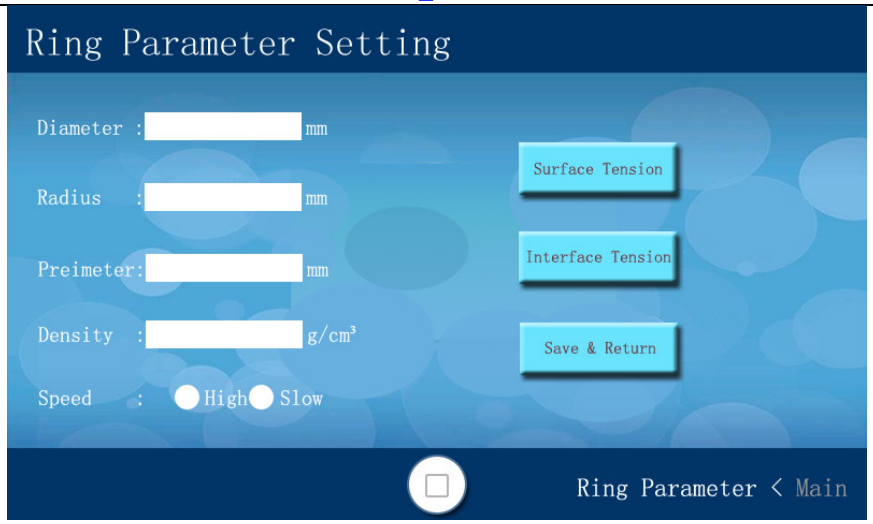
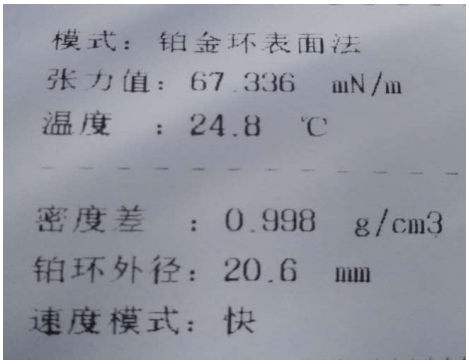


Figure 4 Parameter setting for platinum ring method

It is extremely easy to use this instrument. Due to the high sensitivity to external factors, such as cleanliness and temperature, you must strictly comply with the precautions to minimize any human error during the measurement process.



The above picture is the printed result.

Online measuring procedures:

Platinum plate measuring screen

First, turn on the instrument, power on the computer, and start the application program (automatic tension meter. EXE) whose main screen is shown in Figure 5.

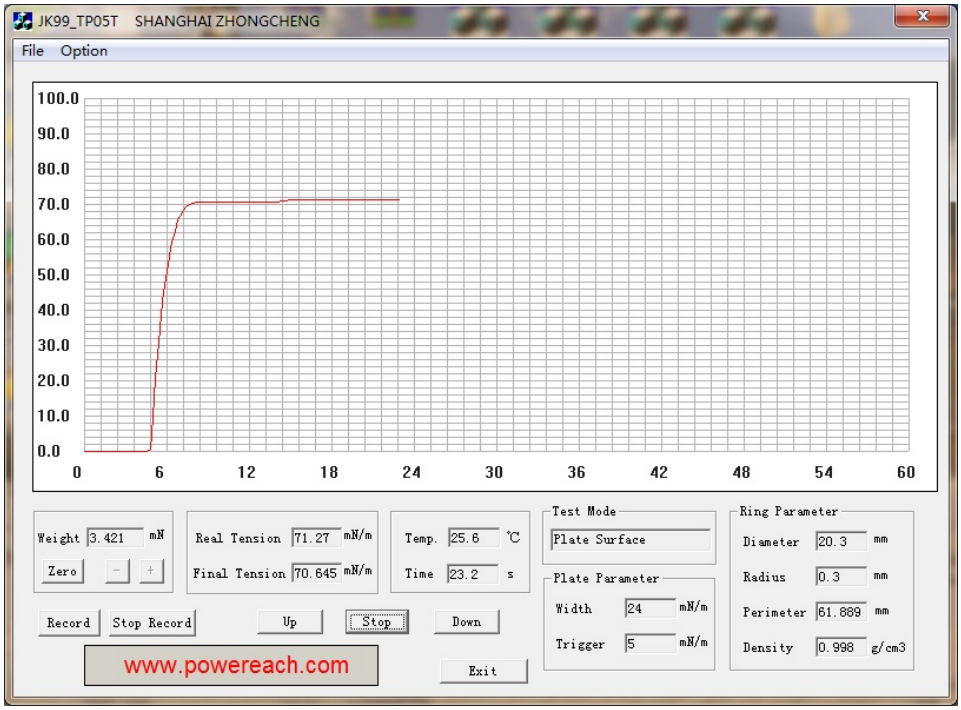


Figure 5 Main screen of the program

Second, click "connect" in the "option" menu as shown in Figure 6 to connect the computer with the instrument; the default port is COM1. In the case of successful connection, the real-time data on the up right corner of the screen will be updated incessantly; otherwise, "connect error" will be displayed.

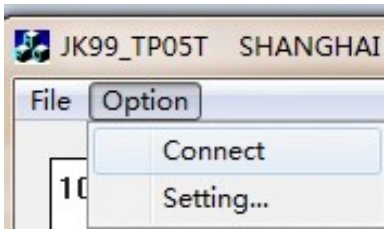


Figure 6 Connection screen

Third, hang the platinum plate onto the hook and click "setting" on the "option" menu to set the measuring mode, perimeter of the plate, triggering value, as shown in Figure 7. Note: Select surface tension mode in platinum plate method if you want to measure a liquid-gas interfacial tension; in this case, the plate perimeter, which may affect the measured value, is set as 24; the triggering value is the parameter used for controlling sample platform movement. If the measured surface tension value is too low or the liquid is viscous, please change this value. Generally, the trigger value is 5 mN/m in the case of measuring any liquid-gas interfacial tension.

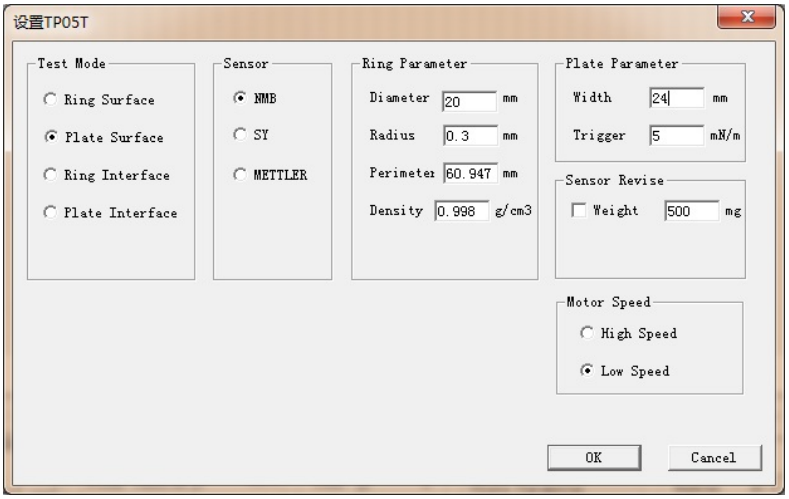


Figure 7 Setting screen

Fourth, "clear" the software by pressing the "clear" button on the screen.

Fifth, clean the platinum plate by the following steps:

1. Hold the plate with tweezers and rinse it with running water. In rinsing the plate, the a certain angle should be kept between the plate and the water such that the water flows through the surface as much as possible without causing any deformation of the plate;
2. Heat the platinum plate with the alcohol burner at a horizontal angle of about 45 degrees until the plate turns to slightly red, which takes about 20 seconds to 30 seconds.
3. Precautions: Clean the plate with clean water in general cases or with acetone or 20% HCL (heating for 15 minutes) in the

case of organic liquids or other contaminants. Then, rinse the plate with water and dry it with the alcohol burner.

Sixth, add the liquid into the sample vessel, clean the external wall of the vessel and put it into a thermal insulation holder. (Note: it is recommended to take a sample for the middle part of the liquid with a pipette and ensure the cleanliness of the glass vessel before taking the sample).

Seventh, after everything is ready, press "test" to start recording and the curve of the surface tension will be displayed on the screen. Apart from recording the surface tension values, you can also select "file" →"save file..." to store the results.

Eighth, repeat the measurement process.

Press "stop" button and wait until the sample platform stop moving downward; press "test" button again and look at the readings. At this time, you need not pay attention to the residual value displayed on the screen. Generally, it is not needed to clean the platinum plate again unless this value exceeds 5 mN/m.

Platinum ring measuring screen

First, turn on the instrument, power on the computer, and start the application program (automatic tension meter platinum ring method EXE) whose main screen is shown in Figure 8.

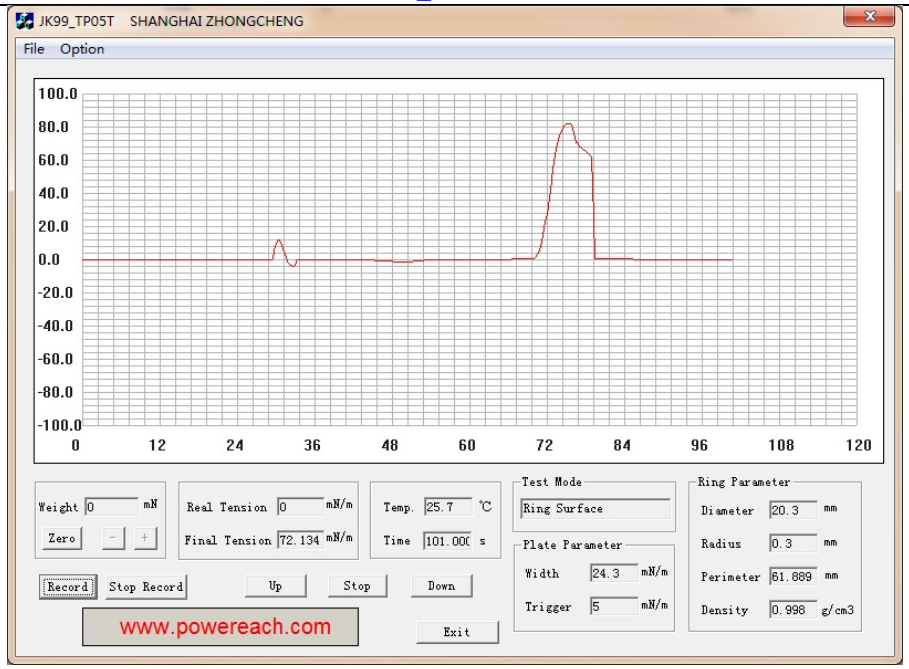


Figure 8 Main screen of the program

Second, click "connect" in the "option" menu as shown in Figure 6 to connect the computer with the instrument; the default port is COM1 port. In the case of successful connection, the real-time data on the up right corner of the screen will be updated incessantly; otherwise, "connect error" will be displayed.

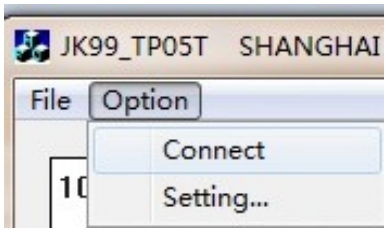


Figure 9 Connection screen

Third, hang the platinum ring onto the hook and click "setting" on the "option" menu to set the measuring mode, diameter of the ring, radius and density (the difference of densities of the two materials that form the interface; for example, it means the difference of water density and air density in the case of the surface tension of pure water; the difference of water density and benzene density in the case of the water-benzene interfacial tension) triggering value, as shown in Figure 11. You can fill in any necessary information into the "note" box.

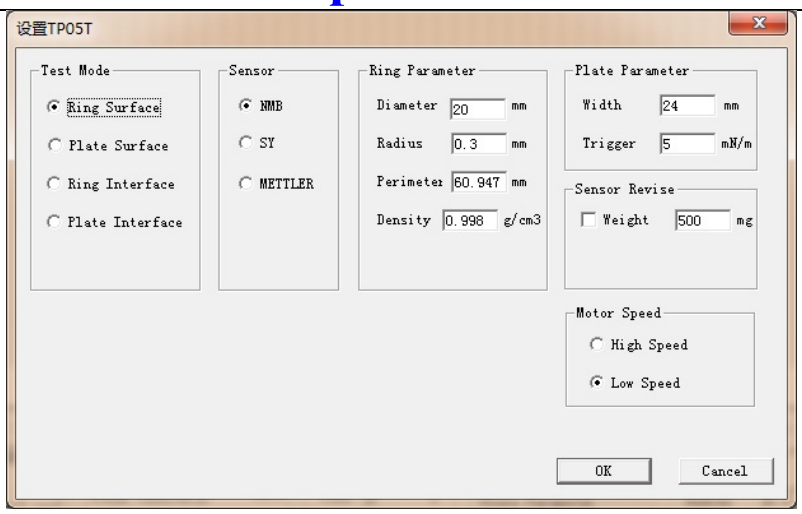


Figure 11 Setting screen

Or you can clear the software with the "clear" button on the screen.

Fourth, clean the platinum ring by the following steps:

1. Hold the ring with tweezers and rinse it with running water. In rinsing the ring, the a certain angle should be kept between the ring and the water such that the water flows through the surface as much as possible without causing any deformation of the ring;

2. Precautions: Clean the plate with clean water in general cases or with acetone or 20% HCL (heating for 15 minutes) in the case of organic liquids or other contaminants. Then, rinse the plate with water and dry it with the alcohol burner.

Fifth, add the liquid into the sample vessel, clean the external wall of the vessel and put it into a thermal insulation holder. (Note: it is recommended to take a sample for the middle part of the liquid with a pipette and ensure the cleanliness of the glass vessel before taking the sample).

Sixth, after everything is ready, press "test" to start recording and the curve of the surface tension will be displayed on the screen. Apart from recording the surface tension values, you can also select "file" →"save file..." to store the results.

Seventh, repeat the measurement process.

Press "stop" button and look at the readings. At this time, you need not pay attention to the residual value displayed on the screen.

Generally, it is not needed to clean the platinum ring again unless the weight value exceeds 0.5 mN.

Attachment: List of buoyancy corrections:

Please apply the appropriate buoyancy correction to your calculation if you require measurement results with high precision:

specific weight	correction coefficient		displayed value		actual value
0..5	0.9954	×		=	
0.6-1.4	1				
1.5	1.00466				
1.6	1.00559				
1.7	1.00653				
1.8	1.00747				
1.9	1.00841				
2.0	1.00936				

2. Measure liquids with high or middle viscosities

This section is used to measure liquids whose viscosity during the measurement exceeds 500CP.S. For these liquids, such as glycerol and viscose, the measured value cannot be stabilized until 5 minutes after the measurement starts (without considering any time-vary property of the liquid).

Method one. Manual mode:

1) Hang the platinum plate and reset the instrument to zero;

2) Move the sample platform upward until it touches the platinum plate by the following steps:

   a) Press "up" button to move the platform upward; b) press "stop" button when the sample surface is about 1 mm away from the plate.

3) Take off the plate and have it wet for 5 mm in height (the height should not be too large; if the displayed value after the plate is hung exceeds 5 mN/m, please slightly scratch the plate on the sample surface until the displayed value is lower than 5 mN/m).

4) Hang the plate again; at this moment, the liquid touches the plate and surface tension occurs to wet the plate.

5) Record the measured value after the value becomes stable.

Method two. Automatic mode:

Automatic mode is recommended (resort to the third method if you require a less time-consuming method).

1) Hang the platinum plate and reset the instrument to zero;

2) Take off the plate and wet it to 5 mm in height;

3) Slightly wipe a part of liquid on the plate with facial tissues;

4) Hang the plate again (if the displayed value is higher than 0, do not reset again; if the displayed value is higher than 5mN/n, wipe more liquid);

5) Press the "test" button to start the measuring process and record the stabilized value.

Method three. Fast manual mode:

As indicated in step 1 to step 4 in method one, immerse the plate into the liquid with an external force which should be as close to the liquid surface tension as possible. For example, if the surface tension is 25, displayed value after the plate is immersed into the liquid is about 23 and 24. This method can easily measure the surface tension of a highly viscous liquid in a short time.

3. Measure surfactants

The surface tension of surfactant is special. Once a pure surfactant is added into another liquid, the surface tension of the mixed liquid will change with time. The surface tension values of samples doped with different amounts of surfactant are different; but the surface tension will not change when the doping amount exceeds a critical value, i.e., CMC. See relevant reference for more information. This instrument can easily measure the surface tension that changes with time.

1) Prepare (warming-up, cleaning, sample preparation, etc.);

2) Pour the sample into the glass vessel at about 80% of its height;

3） Pour more than 1/3 of the sample from the vessel to create a new surface;

4） Measure the surface tension value in such away as indicated in the standard method and observe the curve of surface tension versus time. Usually, the surface tension at a certain time point is used as the reference surface tension as designated by users.

Precautions:

1） According to experience, the above- mentioned time point varies from one industry to another;

2） It is better to use mole as the unit for sample preparation and prepare samples with different moles of the surfactant to observe the CMC. Also, CMC value can be obtained in the following way but you need to calculate the mole quantity with a separate software. The instrument can display the inflection point of the surface tension curve.
Take a certain amount of water and add a small amount of surfactant to the water, then add equal amount of surfactant again and again until the inflection point occurs. The adding amount is determined by the sample amount.

3） The surface tension value in the case of surfactant with a low concentration will change with the amount of the surfactant that stick to the liquid surface. Since the surface condition changes all time, the surface tension value cannot be stabilized until the surfactant on the surface reaches its equilibrium. In some cases, about 4 to 5 hours are needed before the equilibrium is reached.

4. Measure interfacial tension

Cleanliness of platinum plate and platinum ring plays a more important role in measuring interfacial tension than in measuring surface tension.
Method one: measure the interfacial tension when the specific weight of sample A is higher than that of sample B (such as water-benzene and water-oil interfaces)

1） Use a higher glass vessel, cuvette is recommended and pour sample A to the vessel at about 10 mm in height.

2） Pour sample B into the glass vessel until the liquid level is about 15 mm.

3） Place the mixed sample on the sample platform.

4） Take a small quantity of sample A and pour it to another glass vessel. After everything is prepared, immerse the platinum plate to sample A for about 10 mm in depth and take it away from the liquid at an angle.

5） Hang the plate to the hook and ensure the plate touches sample A when it is immersed in sample B. If the plate touches sample A, clean the plate and repeat the measurement process until the interfacial tension value is obtained. If the plate cannot be immersed into sample B, move the sample platform to a higher place or increase the quantity of sample B.

6） Set the triggering value as 0.3 mN/m.

7） Press the "test" button to start the measuring process and record the measured value.

Method two: measure samples whose interfacial tension values are lower than 5mN/m

1） Refer to step 1 to step 6 described in method one;

2） Elevate the sample platform manually until the plate touches sample B;

3） Move the sample platform downward manually, read the increasing interfacial surface value until it reaches the peak, and calculate the measured value with the following equation:

Peak value * 0.991=measured value.

Method three: measure with platinum ring method

1） Open the operation program for platinum ring method;

2） Press "up" button to immerse the platinum ring below the interface of two liquid;

3) Click "setting" in "option" menu, as shown in Figure 10; enter the outer diameter in the "diameter" box and density difference in the "density" box.

4) Reset the software to zero with the "clear" button on the screen.

5) Press "down" button to start measuring the interfacial tension.

6) Press "stop" button when the interfacial tension curve become stable after its peak value and calculate the interfacial tension of the two liquid.

Instrument calibration

➢ Calibration procedures

The instrument has been calibrated before it is shipped and installed. No more calibration is needed unless the instrument has served for a long time or any major error occurs. Calibration procedures are as below:

- The calibration only applies to NMB sensor.
- Click the LCD to enter the calibration screen.
- Press "clear" button.
- Hang the 500 mg weight and enter the weight value to the screen. Observe the measured values to determine if calibration is needed. If major errors occur, click "calibration".

Appendix

➢ Undertaking

Please do not hesitate to contact POWEREACH® if you encounter any problem that cannot be easily solved. If telephone contact is not a convenient choice or the problem is complicated, or you have any better suggestion, please contact POWEREACH® via email. POWEREACH® will make rapid replies once receiving the emails. You will be greatly appreciated if you can notify POWEREACH® of special circumstances found in measuring special samples.

Appendix 1: Surface tensions of some liquids at 20 ℃

Table 2 γ values of some liquids (20℃)

Liquid	γ(mN•m^{-1})	
	Liquid-vapor	Water-liquid
Water	72.75	
Octane	21.69	51.68
Dodecane	25.44	52.90
Hexane	27.46	53.77
Benzene	28.88	35.0
Carbon tetrachloride	26.77	45.0
Octane	27.53	8.5
Butane	24.6	1.6
Aniline	42.9	5.9
Diethyl ether	17.0	10.7
Ethyl acetate	23.9	~ 3
Mercury	484	426

Appendix

2: Water densities, viscosities and water-air interfacial tensions at different temperatures

Table 3 : Water densities, viscosities and water-air interfacial tensions at different temperatures

t/℃	d/(g•cm^{-3})	η/(10^{-3}Pa•s)	γ/(mN•m^{-1})
0	0.99987	1.787	75.64
5	0.99999	1.519	74.92
10	0.99973	1.307	74.22
11	0.99963	1.271	74.07
12	0.99952	1.235	73.93
13	0.99940	1.202	73.78
14	0.99927	1.169	73.64
15	0.99913	1.139	73.49
16	0.99897	1.109	73.34
17	0.99880	1.081	73.19
18	0.99862	1.053	73.05
19	0.99843	1.027	72.90
20	0.99823	1.002	72.75
21	0.99802	0.9779	72.59
22	0.99780	0.9548	72.44
23	0.99756	0.9325	72.28
24	0.99732	0.9111	72.13
25	0.99707	0.8904	71.97
26	0.99681	0.8705	71.82
27	0.99654	0.8513	71.66
28	0.99626	0.8327	71.50
29	0.99597	0.8148	71.35
30	0.99567	0.7975	71.18
40	0.99224	0.6529	69.56
50	0.98807	0.5468	67.91
60	0.96534	0.3147	60.75

Table4 Ethanol-air interfacial tensions at different temperatures

t/℃	d/(g•cm^{-3})	γ/(mN•m^{-1})
0	0.8036	24.05
10	0.7979	23.14
20	0.7895	22.32
30	0.7810	21.48
40	0.7720	20.60
50	0.7632	19.80
60	0.7544	19.01